Example 3

This example was the same apparatus as Example 2. Results are shown in FIG. **5**. Target of operation was <100 ppm CO, with reasonable H_2 consumption and reasonable efficiency. Testing was conducted over several days. Flow rates and temperature were varied to achieve low CO reformate (<100 ppm) at various power outputs. The results are shown in FIG. **5**. All results shown were obtained at full conversion of methanol. The methanator consumed about 15 to 20% of the hydrogen produced in the steam reformer. Power outputs from 11 We up to 22 We were obtained with substantially less than 100 ppm CO. This device is designed to provide hydrogen for low temperature PEM fuel cell.

Example 4

This Example used apparatus of the same design as Examples 2 and 3 except that the combustion chamber contained a staggered combustion catalyst. The device volume and mass were the same as example 1. Testing was conducted at 9-28 W, 248-294 C reformer temperature; and 225-273 C methanator temperature. The results are shown in FIG. **6**. All results shown were obtained at full conversion of methanol under steady-state conditions. This device demonstrated an operating range of 9 to 28 watts under the conditions tested. Therefore this device has a power density of approximately 1.2 kW/L and a specific power of 224 W/Kg. It is likely this range could be expanded if explored more thoroughly. For all these operating conditions, the CO level was maintained at less than 100 ppm (except for two data points), while the thermal efficiency of the device ranged from 46% up to 67%, with hydrogen consumption ranging from 9% to 24%. The improved selectivity is believed to be due to the reduced hot spot in the steam reformer. This device is designed to provide hydrogen for low temperature PEM fuel cell.

Example 5

This Example used the same type of apparatus as Example 4 with target power output of 20 W over time to show stability of operation. This device was operated for about 2.5 hours continuous operation at 16-18 W output, and showed stability of operation, despite the absence of a feedback-loop based control system in this proof-of-principle laboratory setup. Over the course of the demonstration, the reactor maintained low CO levels between 13 and 24 ppm. At the same time, thermal efficiency ranged from 51% to 60%, and hydrogen consumption ranged from 15% to 23%. This device is designed to provide hydrogen for low temperature PEM fuel cell.

We claim:

1. A compact steam reformer, comprising:

a reactant preheat section;

a steam reforming reaction chamber comprising a steam reforming catalyst;

wherein the steam reforming reaction chamber is in conductive thermal contact with the reactant preheat section such that, during operation, heat from the steam reforming reaction chamber can be conducted directly across a reaction chamber wall into the reactant preheat section;

wherein the reactant preheat section comprises an inlet and an outlet, and wherein the reactant preheat section outlet is disposed such that, during operation, flow from the reactant preheat section outlet flows into the steam reforming reaction chamber;

a combustion chamber adjacent to the steam reforming reaction chamber and separated from the steam reforming reaction chamber by a chamber wall;

wherein the combustion chamber comprises a combustion catalyst and wherein the combustion chamber has a length and wherein the combustion chamber length is defined in the direction of flow through the combustion chamber, and begins at a point where flow first encounters catalyst and ends where flow last encounters catalyst; and

a combustion preheat chamber;

wherein the combustion chamber is in conductive thermal contact with the combustion preheat section such that, during operation, heat from the combustion chamber can be conducted through a combustion chamber wall into the combustion preheat section;

wherein the combustion chamber comprises an inlet and an outlet, and wherein the combustion chamber outlet is disposed such that, during operation, flow from the combustion chamber outlet flows into the combustion preheat section.

2. The compact steam reformer of claim **1** further comprising a methanation catalyst disposed in the reactant preheat section.

3. The compact steam reformer of claim **1** wherein the reactant preheat section comprises methanator, vaporizer and superheat subsections.

4. The compact steam reformer of claim **1** comprising a stack of layers, comprising the following layers in sequential order:

a methanation layer comprising a methanation catalyst;

a vaporizer layer;

a superheat layer;

the steam reforming reaction chamber;

the combustion chamber; and

a preheater layer.

5. The compact steam reformer of claim **4** comprising at least 3 preheat layers in the combustion preheat chamber.

6. A compact steam reformer, comprising:

a reactant preheat section;

a steam reforming reaction chamber comprising a steam reforming catalyst;

wherein the steam reforming reaction chamber is in conductive thermal contact with the reactant preheat section such that, during operation, heat from the steam reforming reaction chamber can be conducted directly across a reaction chamber wall into the reactant preheat section;

wherein the reactant preheat section comprises an inlet and an outlet, and wherein the reactant preheat section outlet is disposed such that, during operation, flow from the reactant preheat section outlet flows into the steam reforming reaction chamber;

a combustion chamber adjacent to the steam reforming reaction chamber and separated from the steam reforming reaction chamber by a chamber wall;

wherein the combustion chamber comprises a combustion catalyst; and

a combustion preheat chamber;

wherein the combustion chamber is in conductive thermal contact with the combustion preheat section such that, during operation, heat from the combustion chamber can be conducted through a combustion chamber wall into the combustion preheat section;

wherein the combustion chamber comprises an inlet and an outlet, and wherein the combustion chamber outlet